DOCUMENT RESUME

ED 106 086 88 SE 018 497

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TITLE Sounds and Noises. A Position Paper on Noise Pollution.
INSTITUTION Environmental Education Center, Oteen, N.C.; Madison County Public Schools, Marshall, N.C.
SPONS AGENCY Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE [74]
NOTE 84p.

EDRS PRICE MF-$0.76 HC-$4.43 PLUS POSTAGE
DESCRIPTORS *Acoustics; Elementary Secondary Education; *Environment; *Environmental Education; Environmental Influences; Learning Activities; *Pollution; *Science Education
IDENTIFIERS Elementary Secondary Education Act Title III; ESEA Title III; *Noise Pollution

ABSTRACT

This position paper focuses on noise pollution and the problems and solutions associated with this form of pollution. The paper is divided into the following five sections: Noise and the Ear, Noise Measurement, III Effects of Noise, Acoustics and Action, and Programs and Activities. The first section identifies noise and sound, the beginnings of noise pollution, and describes the progress of hearing. A diagram of the ear is included. Noise Measurement, the second section, considers the hearing process, decibles, and sources of noise pollution. The third section, Ill Effects of Noise, examines some of the psychological and physiological effects produced by noise pollution. The fourth section introduces acoustics and outlines some measures for combating and controlling noise. The fifth section, Programs and Activities, suggests activities which can be used to explore noise and noise pollution. A glossary and bibliography are included. (TK)

ED106086

# SOUNDS AND NOISES

by

Thomas L. Chapman

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# CLOSSARY

| | | |
|---|---|---|
| 1. | abatement | making or becoming less, to end |
| 2. | acoustical | the qualifying objectives, acoustic and acoustical mean containing, producing, arising from, activated by, related to, or associated with sound |
| 3. | ambient noise | the all-encompassing noise associated with a given environment, being usually a composite of sounds from many sources near and far |
| 4. | annoyance | displeasure or resentment caused by some irritant; either by its physical presence or because of the implications arising out of its presence |
| 5. | audio | pertaining to sound and hearing sensations |
| 6. | audiometer | an instrument for measuring hearing acuity |
| 7. | Bel | named after Alexander Graham Bell, the Bel is the unit of measuring sound loudness |
| 8. | boilermaker's deafness | gradual cumulative loss of hearing resulting from repeated exposure to very intense noise, all day and every day for months and years |
| 9. | cycle | a cycle is the complete sequence of values of a periodic quantity which occur during a period of time |
| 10. | Dayton Miller | this man is credited with the most accurate measurement of the speed of sound; in 1934 he measured it at 1087 ft. per second or 740 miles per hour |
| 11. | decibel | the most common measurement of measuring sound intensity, it equals only 1/10 of a Bel |
| 12. | doppler effect | when a source of sound or a listener, or both are in motion relative to the air, the pitch of a sound, as heard by the listener, is in general not the same as when source and listener are at rest<br><br>most common example - sudden drop in pitch of the sound from an auto horn as one meets and passes a car proceeding in the opposite direction |

13. echo — reflected sound which arrives a long enough time after it's direct equivalent for it to be heard as a separate sensation

14. frequency — rate of recurrence; the number of periods or regularly occurring events of any given kind of unit of time; the number of cycles or completed alternations per unit time of a wave of oscillation

15. green belt — belts of bushes and trees which if planted along highways and roads can effectively diminish highway rumble

16. hearing loss — the hearing loss of an ear at a specified frequency is the amount, in decibels, by which the threshold of audibility for that ear exceeds the normal threshold

17. hearing spaces — where listening attentively to the source is the principal activity within the room. Theaters, concert halls, churches, lecture halls, etc. are typical examples

18. impacted wax — nature's defense against insects and water is the wax that is formed by skin glands in the ear canal. But sometimes wax is formed in excessive amounts and forms a hard mass that may stick to or press against the drum membrane or may completely plug the canal

19. infrasonic frequency — a frequency too low to excite the sensation of hearing in humans

20. loudness — an observer's auditory impression of the strength of a sound

21. masking — a screen covering; to conceal; the process by which the threshold hearing of one sound is raised due to the presence of another sound

22. muffler — a special duct or pipe that impedes transmissions of sound while permitting the free flow of air; any of various devices for the deadening of sounds by wrapping or other means

23. nerve deafness — may result as an injury to the sense organ (cochlea) or the auditory nerve, shows reduced sensitivity for bone conduction as well as for air conduction

| | | |
|---|---|---|
| 24. | noise | sound, especially loud, harsh of a confused kind; unmusical or confused sounds; clatter, clamor, racket; sound which is undesired by the hearer; unwanted sound |
| 25. | noisy | where a general impression of "loudness" or elevated sound level is immediately apparent when entering the range of the sound waves |
| 26. | normal noise | where communications, normal human activities are conducted |
| 27. | very noisy | airports, railroad stations and other environments in which conversation often takes place at elevated decibel levels, and humans are glad to leave the place for relief from the noise |
| 28. | noise climate | the average level of continuing noise or sound from various continual activities in an area; the average or usual level of noise in an area such as an office or ball park, etc.; example - a person is less likely to be disturbed by loud noise in an area where the noise climate is high than he would be if he was used to being in a low noise climate area |
| 29. | oscillation | variation in the magnitude of a quantity above and below a certain level over a period of time; as the pressure of a sound wave |
| 30. | pitch | is determined by the frequencey of the sound impulses sent out by the vibrating source; degree of height or depth of a tone or of sound, depending upon the relative rapidity of the vibrations by which it is produced |
| 31. | porous | full of pores or holes, porous materials absorb sound well and are used as sound insulators |
| 32. | presbycusis | the loss of sensitivity for tones of high frequency that is to be expected as part of the average human aging process. The average expected hearing loss at 60 years of age is 32 dB for men and 17dB for women. The basis of the hearing loss is a degeneration of, for no presently assignable cause other than age, some of the hair cells toward the nasal end of the cochlea |
| 33. | quiet | where a minimun of background sound is acceptable. Radio studios, sleeping rooms, etc. fall into this group |

| | | |
|---|---|---|
| 34. | random noise | noise due to the aggregate of a large number of elementary disturbances with random occurence of time |
| 35. | refraction | a bending of sound waves in layers of air at different temperatures. This is due to a greater speed of sound in warm air than in cold air |
| 36. | resonance | when a system is vibrating as a result of a forced excitation at a certain frequency, if the amplitude of vibration diminishes as a result of raising or lowering the frequency of the exciting force, then the system is a resonance; reverberation; the state of a system in which an abnormally large vibration is produced in response to an external stimulus occurring when the frequency of the stimulus is the same or nearly the same, as the original frequency of the system |
| 37. | semi-circular canals | these organs of balance are in the inner ear; they can be affected and upset by noise causing headaches and dizziness |
| 38. | sonic boom | a loud noise caused by a shock wave generated by an aircraft moving at a supersonic speed, i.e. faster than the speed of sound which is 740 mph |
| 39. | sound | the sensation produced by stimulation of the organs of hearing by vibrations transmitted through the air or other mediums |
| 40. | sound barrier | a hypothetical barrier to flight beyond the speed of sound, so postulated because aircraft undergo an abruptly increasing drag force induced by compression of the surrounding air when travelling near the speed of sound |
| 41. | sound intensity | the power flowing through one square meter of area, taken normal to the direction of the wave |
| 42. | sound power | of a source, the total sound energy radiated per unit time. The unit is the watt |
| 43. | sound transmission | the transfer of sound energy from one medium to another |
| 44. | sound wave | a disturbance whereby energy is transmitted in a medium by virtue of the inevitable; elastic and other dynamic properties of the medium, a longitudinal wave in an elastic medium, esp. a wave producing an audible sensation |

| | | |
|---|---|---|
| 45. | tinnitus | a "ringing in the ears" seems to be a symptom of any sort of irritation of the hearing organ. A little "head noise" is so common as to be normal. Tinnitus may be greatly increased by the mechanical insult of exposure to very loud sounds |
| 46. | tone | any sound considered with reference to its quality, pitch, strength, source, etc.; a musical sound of definite pitch |
| 47. | ultrasonic frequency | a frequency too high to excite the sensation of hearing in humans |

# NOISE AND THE EAR

## BEGINNINGS OF NOISE POLLUTION:

Oral communication began with primitive man. As man began to live in groups he needed a system of communication for hunting and relating danger to one another. Thus, the first attempts at language and audible communication developed out of necessity. As mankind evolved into a more sociable animal and began to develop his society and make tools, the sound of his existence covered the earth.

The Old Testament mentions the clatter of stone handmills.[1] John C. Webster of the U. S. Navy Electronics Lab pointed out that:

"Deafening effects of noise probably started with the discovery of gun powder, or at least with the Industrial Revolution..."[2]

However, noise pollution is almost as old as man and his civilizations. "The Rienows in Moment In the Sun note that Julius Caesar was so incensed with the clatter of chariots that he declared a ban on their use after sunset."[3] "Eyewitnesses in ancient Rome wrote that even before sunrise, the hammering of metal workers and the yelling of children were deafeningly combined with cries of bakers and cowherds hawking their bread and milk. Silence was held off throughout the day by cattle herded through the streets, peddlers crying their wares, mountebanks singing and strumming, town criers giving loud oral notice that some jewelry or slave was lost, that a shop was for sale, that dwellings were available for rent. Punctuating the voices of animals and men were the musical instrument-makers' off-notes, the clatter of wagon and chariot wheels on the cobblestones, the staccato of smiths and carpenters."[4]

More than one visitor to London in the Middle Ages wrote home about

the awful clamor of horses' hooves and wagon wheels on cobblestone streets, the infernal clackings of women's shoes on sidewalks and the cacophony of fish peddlers, ironmongers and pitchmen shouting for sales."[5] And as civilizations grew in population and industry, the din of noise increased. In the magazine, "Environmental Quality", Ralph Hausser wrote:

"The true assault of noise began with the industrial revolution. Quiet towns saw the growth of steam power plants, boilermaker works and textile mills whose whirring, clacking machinery has been known to reach as high as 103 decibels of constant ear-wracking sound. The term "boilermaker's ear" was coined to describe the serious effects on hearing experienced by men working in these plants.

The development of the internal combustion engine, the jet engine, pneumatically operated tools such as jack hammers, and rivet guns and, perhaps almost ironically, labor saving appliances and entertainment systems for the home are the latest in a series of technical developments that have brought with them the raising of the racket which the average person is now forced to live with. What was once largely an urban problem has spread to the suburbs and rural areas."[6]

Noise has been described as "unwanted sound" or those sounds that are irritating to people. Robert Alex Baron, head of Citizens for A Quieter City says: "In general, sound is noise when its physical components disturb the relationship between man and his fellow man, and man and his environment. Or, when the acoustic energy causes undue stress and actual physiological damage. In conventional terms, sound may be classified as noise when it damages the hearing mechanism, causes other bodily effects detrimental to health and safety, disturbs sleep and rest, interferes with conversation or other forms of communication, annoys or irritates."[7]

However, while defining "noise" as unwanted sound we must sometimes qualify that classification by stating that it is noise only to the receiver that becomes irritated or annoyed by its presence. In other words, sound may be noise to some people but "music" to others. A good example is rock music. How many mothers have complained of that "awful noise" that their teenagers call "good music"? And what about motorcycle enthusiasts? The roar of their well-tuned cycles is "music to their ears" but terrible noise to someone who doesn't like it. So there are qualifications to defining "noise" or "noise pollution".

"Sounds called musical are usually rather regular disturbances of the air, irregular and erratic disturbances are usually unpleasant to hear and are termed noise. Thus, noise, in a general sense, is any more or less random noise."[8]

At any location there is always some noise. Usually the noise comes from many sources near and far; it may be reflected from walls, and parts of it probably come from all directions. This composite all-encompassing noise associated with a given environment is called "ambient noise".

However, it is generally safe to say that any loud or potentially irritating or annoying sound is "noise" or "noise pollution". Noise pollution is a term used to define the conglomeration of noises that permeate our society. An article that appeared in the Milford Cabinet in Milford, N. H. on July 4, 1968 best describes noise pollution. It read:

"Now-Noise Pollution."......Noise pollution is what we suffer from when we sit on the rocks looking out to sea enjoying the sound of the wind and the waves, but not enjoying at all the blast of soul music from the transistor radio on a nearby table.

Noise pollution is what shatters the neighborhood calm when one of those undersized motorcycles without a muffler goes up the road in the evening. Noise pollution is the convertible with the top down and radio turned up high, which parks in front of the house before taking off with a screech of tires on asphalt...

Noise pollution emanates from the whole gamut of bulldozers, tractors, loaders, scrapers and trucks that we accept as the tools of our civilization. Noise pollution is the high-powered outboard motor, which scatters a flock of ducklings and destroys any illusions of peace that might have been sought by people along the shore of any of a thousand New England lakes....."[9]

DESCRIBING THE PROCESS OF HEARING:

The human ear is truly a marvelous organ. In addition to being the organ of hearing, it also controls our balance through the semi-circular canals. The ear consists of three distinct areas: the outer ear or the part you see, the middle ear and the inner ear. The following description of the anatomy of the ear was from a Noise Pollution module booklet written by Thelma S. Graeb. Please refer to the drawing (page12) for a picture of the human ear.

"The outer ear is composed of the external ear (pinna) and the ear canal (external auditory meatus). What we commonly refer to as an "ear" is, in fact, only the outer ear. The function of the outer ear is to collect sound waves approaching the ear and to conduct these waves in a more concentrated form to the ear drum.

The middle ear begins at the ear drum (tympanic membrane) and contains the three smallest bones of the body, called the hammer (malleus), anvil

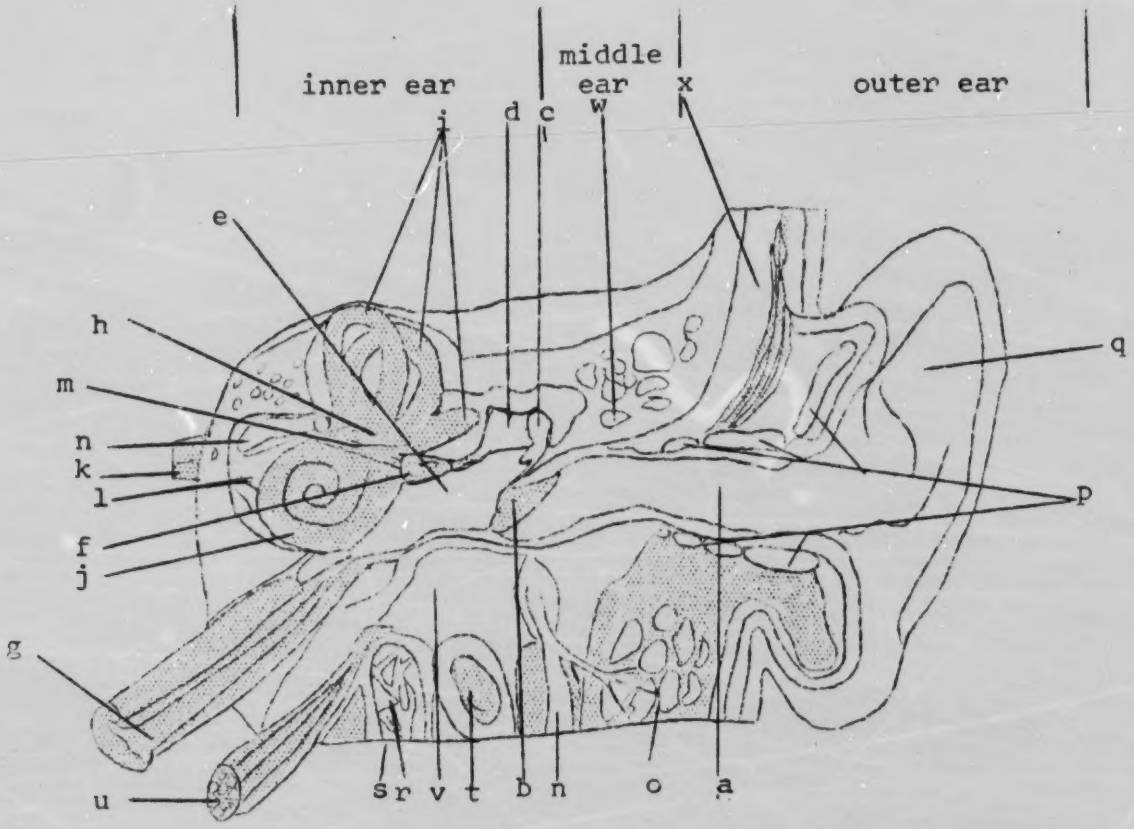
(incus), and stirrup (stapes). These tiny bones are connected in a chain-like fashion, being attached at one end to the inside of the eardrum and at the other, to the membrane covering the inner ear and it's viscous fluid. Upon movement of the eardrum, this bony chain moves inward, transmitting the pressure wave to the heavy inner ear fluid where electron-chemical impluses take place and initiate auditory impluses which are sent to the brain. Also in the middle ear are two muscles, the tensor tympani and the stapedius, which help to prevent the transmission of potentially overpowering vibrations to the inner ear. The middle ear also contains the Eustachian tube which extends from the floor of the middle ear cavity into the throat and helps to ventilate the middle ear and equalize pressure. For example, people feel discomfort in their ears after a rapid descent in an elevator or airplane; swallowing, however, relieves the discomfort. What actually is occurring is an equalization between environmental pressure and pressure within the middle ear cavity.

The inner ear contains the semi-circular canals, the sense organ of balance, and the cochlea, or sense organ of hearing. Vibrations of the footplate of the stirrup (stapes) which contains the oval window, causes the fluid (periphylymph) in the cochlea to move.

The snail-shaped organ (cochlea) is divided into an upper portion (scala vestibuli) and a lower portion (scala tympani), both containing fluid (periphylymph). The triangular compartment (scala media) is formed on the lower side by a bony ridge (osseous spiral lamina) and the basilar membrane which is also attached to the spiral ligament. The cochlea duct is filled with fluid (endolymph). The organ of Corti is located on the basilar membrane and contains the hair cells (sensory end-organs) which

are attached to the gelatinous tectorial membrane. The hair cells are arranged in rows: one row of inner hair cells and three or more rows of outer hair cells. High-frequency tones are transmitted at the basal end of the cochlea, while low-frequency tones are transmitted near the apex. Middle frequencies activate the second turn area of the basilar membrane. The fluid movement causes the membranes to move, thereby stimulating the hair cells which trigger electrical impluses that activate the fibers of the 8th cranial (auditory) nerve. The nerve transmits these impulses to the brain which interprets the sounds it receives from the ear.

In summary, the ear functions by transforming a vibrating source from acoustic energy into mechanical energy in the middle ear, into hydraulic energy in the inner ear, into electrical impulses along the 8th nerve, and finally into psychological or semantic impulses at the auditory cortex."[10]




a. Auditory Canal
b. Ear Drum
c. Hammer
d. Anvil
e. Stirrup
f. Oval Window
g. Eustachian Tube
h. Vestibule
i. Semicircular Canals
j. Cochlea
k. Auditory Nerve
l. Cochlear Nerve
m. Vestibular Nerve
n. Facial Nerve
o. Salivary Gland
p. Cartilage of Ear
q. Helix
r. Sympathetic Nerve Plexus
s. Internal Carotid Artery
t. Internal Jugular Vein
u. Soft Palate Muscle
v. Mastoid Process
w. Petrous-Type Bone
x. Temporal Muscle

# NOISE MEASUREMENT

## THE HEARING PROCESS:

"Sound is the result of two processes: (1) a physical change in the environment relating to pressure and (2) a psycho-physical process which involves the transmission, perception and interpretation of the sound in one's consciousness.

The first stage of sound production is the creation of sound waves (vibration of air particles) which are set into motion in all directions from a central vibrating source, e.g. a vibrating string on a musical instrument that has just been plucked. The moving air particles cause pressure variations in the surrounding air, which eventually reach the ear and bring about similar pressure changes or impulses at the highly sensitive eardrum; this then starts the psychophysical process of "hearing". The two main qualities which we use to identify and describe sound waves are frequency (pitch) and intensity (loudness).

The frequency or wave length is determined by the number of vibrations or cycles per second (cps). The greater the number of vibrations per second, the higher the pitch. The musical note middle C is produced by 256 cps. The human ear can respond to a frequency range from 20 to 20,000 cps. The most sensitive range is from 500 to 4,000 cps. For speech discrimination (the ability to understand speech) the range from 500 to 20,000 is critical, because this range contains the majority of energy present in the speech wave. In order to understand speech one must be able to hear it clearly.

The intensity (loudness) of a sound is determined by the amplitude (force) of the sound wave. For convenience, sound intensity is often ex-

pressed in terms of decibels (dB). The decibel is 1/10 of a Bel and was named after Alexander Graham Bell. A decibel is the logarithmic ratio between two sound pressures with a base reference of 0.0002 dynes per centimeter squared -- 0.0002 dynes/cm$^2$ represents the softest sound audible to the human ear. This corresponds to 0 dB, or zero decibels. These decibels are units of pressure our ears require before hearing sounds of various pitches which are especially important to us, such as those lying within the speech range. The larger the number of decibels the louder the sound. The human ear can adapt to a wide range of intensities, but the upper limit, or the threshold of pain is 120 dB."[11]

"There is no single universally accepted criteria of what constitutes excessive noise. The most common noise yardstick is the decibel scale, which is an expression of the sound pressure that moves the ear. The scale begins at 0 dB, which is the weakest sound that can be picked up by the healthy ear. Thereafter, because of physical laws, the scale increases as the square of the change. Thus, so soft a sound as human breathing is about 10 times greater than zero dB, while an artillery blast is one thousand trillion (1,000,000,000,000,000) times greater (than 0 dB). To simplify things, the scale is in logarithmic form so that ten times the minimum is 10dB and 1,000 trillion times the minimum is 150 dB. The dB scale does not, however, take account of the tones in the sound being registered - i.e., the frequencies of the sound waves being propagated."[12]

Most people are right-eared. They prefer it and hear more accurately with it. However, many people prefer to listen to music with their left ear. Mankind is not particularily good at hearing when compared with many other animals. Horses, rats, dogs, and cats are among the many

animals that can hear higher and lower pitched sounds than man."[13] Infrasonic and ultrasonic frequencies can be heard by cats and dogs but are out of the range of humans. Cats can hear up to 50,000 cycles per second while man's hearing is limited to a range of approximately 20 to 20,000 cps. Bats hear by radar, sound produced by them reflect off an object and is picked up 1 millisecond later. This guides them along a clear path and to food.

"Crickets became a separate evolutionary line some 200 million years ago. The ancestors of the crickets were probably among the first animals to be involved in adding sound to the silent, terrestrial environment of the ancient earth. And even today, crickets produce many of the loudest sounds - some over 100 dB at distances of a few inches.

The sounds emitted by dolphins are of many kinds. Some signals they produce are in our hearing range and resemble the human voice. There is some evidence that dolphins can mimic certain human sounds. The high-frequency sounds emitted by the dolphin are used in its sonar systems for locating and recognizing objects in dark, murky waters.

When a foraging honey bee finds a choice source of food, it flies back to the hive and signals its fellow bees the distance and direction of the tasty morsel. Recent evidence indicates that it is not the dance of the bee that conveys the information but rather a peculiar sound made during the dance. A dancing bee emits a low-frequency of 250 cycles per second. It is through these low-frequency signals that a honey bee communicates with its fellow bees."[14]

In all animals, the shape of the external ear is determined by the animal's need to localize sound. The best position of the head for sound

localizing is to have the sound waves coming straight towards one ear, the wave of greater wave-length meeting the nose-neck axis of the head like a wave against a cliff. That's why we turn our heads or cuff an ear in order to hear sounds more clearly.

DECIBELS:

The following is a list of some of the more common sounds that we hear and their accompanying decibel level. Any prolonged exposure of above 85 decibels (dB) can be dangerous and may result in a permanent hearing loss. The 85 decibel level is called the "threshold of discomfort" and a decibel level of 120 has been termed "the threshold of pain" in hearing. Studies have shown that levels of 160 decibels are lethal to mice and other small rodents. Carefully read the following and rate your environment in terms of quiet, moderate or loud.

| SOURCE | DECIBEL LEVEL |
|---|---|
| Threshold of hearing<br>a quiet church<br>a still night in the country | 0 |
| Soundproof room | 10 |
| Rustling of leaves | 20 |
| Public library | 20 |
| Country road | 20 |
| Average whisper | 20 |
| Quiet radio in home | 40 |
| Average living room | 40 |
| Surburban playground | 40-50 |
| Vacuum cleaner | 60-65 |
| Using telephone is difficult | 60-65 |
| Average traffic | 65-70 |
| Noisy office | 65-70 |
| Portable sander | 80 |
| Food blender | 80 |
| Having to shout to be heard | 80 |
| Telephone impossible to use | 80 |
| Average factory | 85-90 |
| Truck motor racing | 90 |
| Loud public address system | 90 |
| Noisy factory | 95-100 |

| SOURCE | DECIBEL LEVEL |
|---|---|
| Car horn at 3 feet | 100 |
| Loud thunder | 100 |
| Motorcycle | 100 |
| Lawn mower | 100-110 |
| Subway car | 100-110 |
| Riveter | 100-110 |
| Chainsaw | 110-115 |
| Threshold of Pain: | 120 |
| Rock combo | 120 |
| Nearby jet taking off (possible eardrum rupture) | 130 |
| Take-off blast of Saturn V moon rocket | 180 dB |

The noise level that most Americans encounter everyday is frightening. It seems that noise is everywhere and ever present. The affluence of Americans is perhaps the biggest cause of our tremendous noise pollution problem. We have over 100 million cars on the road today in the U.S.A. and close to 20 million trucks and buses. Add to those all the motorcycles, subways, trains, airplanes, and occasional emergency vehicles with their screeching sirens and you have a horrible noise pollution problem in transportation alone. Meanwhile, over 3 million construction workers in the U.S. create a deafening roar daily with jackhammers, rivet guns, earth-moving equipment and a whole host of mechanical noise-makers that operate under the guise of construction machinery.

15

"One's job can be the noisiest experience of the day. If you're a rock-driller at a quarry, you may be experiencing more than 100 dB noise all day. At this level, only about five minutes' worth of noise is the safe daily dose. If you work in the wood products industry (as almost 800,000 American men do) you are also immersed in a sea of noise all day.

A 1956 survey by the U.S. Public Health Service found that operators of saws, planers, routers, molding machines, shapers, jointers, and sanders are exposed to average overall sound-pressure levels which exceed 95 dB. For several of these operations, the average level may be as high as 115 dB."[16]

"In May, 1968, the U.S. Public Health Service published findings from its National Health Survey on the hearing levels of adults of different occupations, income and educational levels. As may have been expected, American adults with more education and higher incomes (reflecting the quieter, professional nature of their occupations) had better hearing than those with less education and lower incomes (reflecting factory and other industrial workers who work in noise but who also may not get adequate medical care). But a surprising finding was that 'hearing impairment was found most frequently among farmers.' This seems erroneous until you think about how mechanized the farm has become. And, as a matter of fact, University of Nebraska researchers in 1968 reported that the farm tractor, in particular, ' produces sound levels capable of causing permanent hearing loss, when used over an extended period of time.' Their levels were 90 to 114 dB."[17]

"Factories, as detailed earlier, can be very noisy working places. North Fleming of Eastbourne, Sussex, measured various kinds of factory noises in England and gathered these data:"[18]

| Factory Operator | dB Level |
|---|---|
| Boiler workers | 118 |
| Metal powder workers | 114 |
| Steel works, fettling | 114 |
| Metal saw | 110 |
| Wood planing machine | 108 |
| Metal working shop | 106 |
| Weaving shed | 104 |
| Sweet-coating machine | 102 |
| Screw-heading machine | 101 |

| Factory Operator | dB Level |
|---|---|
| Casting falling into bin | 97 |
| Envelope machine | 99 |
| Diesel electric generator house | 96 |
| Printing workers | 96 |
| Automatic lathes | 87 |

"Stated categorically below are the number of American workers exposed to noise levels above 90 dB, in the estimation of the Carnegie-Mellon reseachers:

| | |
|---|---|
| Professional, technical, etc. | 865,000 |
| Farming | 3,000,000 |
| Clerical and kindred | 4,265,000 |
| Managerial and official | 2,200,000 |
| Sales | 249,000 |
| Crafts, hand skilled labor | 8,042,000 |
| Operative and kindred | 10,953,000 |
| Household and service | 2,401,000 |
| Labor | 2,102,000 |
| TOTAL | 34,077,000" [19] |

SOURCES OF NOISE POLLUTION:

After working all day most Americans like to go home to relax. Home, in the American mind, is a place of peace and tranquility where quiet and relaxation reign. But alas, that dream is not the real story. In this modern age of mechanical and electrical wonders, the average American home is anything but that haven of quiet that we all seek but few find.

"You need not go farther than your own home to realize how noisy our world is."[20] In the American Journal of Public Health Robert Alex Baron wrote,....."(at home our urban early riser) is bombarded by noise from within his building and from without. He probably is forced to listen to his family's TV set, his neighbors' TV sets, and details of his neighbors' personal lives, as well as to the air conditioners in his own quarters. Any time during the night his sleep may be disturbed by many noise sources: buses, trucks, motorcycles; the sirens of fire engines, police cars, and ambulances; auto horns, barking dogs, planes - and his neighbors' air conditioners."[21]

"During the warm seasons, noises from other households permeate our quiet. Doors slamming, an exuberant group of children enjoying a splash party, cap guns and firecrackers banging, the steady hum of lawn mowers added to a hot, humid day produce a greater awareness of increased noise levels."[22]

While many of us are aware of the bombardment of noise aound our homes, we are not fully aware of the constant din in our own homes. Do you ever wonder why you're so tired every day, even if you stay at home? It could be that you have a noise pollution problem at home! Researchers say that workers spend 15% of their energy fighting noise. Perhaps your subconscience fight against the noise of everyday occurrences around the house is sapping your strength. Let's examine a few rooms of the average, modern American home.

"Indoor noise is familiar to all of us. For example, the kitchen with it's electrical equipment, such as dishwashers, garbage disposals, refrigerators, blenders and exhaust fans is considered the noisiest room in the house. It has hard ceiling, walls and floor surfaces which reflect the sounds instead of absorbing them."[23]

"The racket in a modern American kitchen rises as high as 90 dBA midst an ever expanding profusion of dishwashers, mixers, grinders, exhaust fans, disposers and the like,"[24] says John Mecklin in an article entitled "It's Time to Turn Down All That Noise."

"The living room is not very quiet either. First of all, the sounds of the kitchen often make conversation in the living room impossible. This is especially true in most modern apartments. There are also the television sounds (68 dB at average volume) and hi-fi sound (80dB). And there is the

vacuum cleaner, which makes 73 dB of noise six feet away, when the nozzle is fully engaged in the rug, but 81 dB when the nozzle is lifted from the rug."[25]

"Bedrooms are usually quieter, in the range of 55 dB, but many have incessant air-conditioner sounds."[25] And what about playrooms? In addition to the overall sound of children playing and their screams and whines, toys have added a new dimension to noise pollution in and around the home.

"Without regulations, toys have joined the decibel madness, and are designed with noise as a sales feature. Velocipedes are equipped with simulated motor noises, plus horns. Toy carbide cannons make a mighty roar that can be heard for blocks. The acoustician reviewing a patent for a device designed to sound like a one-cyclinder motorcycle engine was provoked to comment: 'The joy of making noise is the birthright of every youngster, but must he have a battery-powered machine to make it for him?'"[27]

The abundance of motor driven noise monsters adds to the American home. Vacuum cleaners, dishwashers, washers and dryers, hair-dryers and floor polishers are all in constant use. But here are often sources of noise in your home which are not powered by motors.[28] Some of those little things that get on your nerves are worse than loud noises. Houses are often torture chambers to those people who cannot tolerate a constant tink-tink of a dripping faucet or the like. Singing toilets, showers and pipes are non-motorized noises as are T.V.'s, radios, and the neighbor's children or dogs.[29] In Theodore Berland's book, <u>The Fight for Quiet</u>, he states, "Poorly designed ventilating and air-conditioning systems make excellent speaking tubes between apartments or offices."[30] Anyone who has such an apartment or office knows that this is painfully true.

"Alas, the individual consumer cannot demand such decibel specifications for each vacuum cleaner, lawn mower, dishwasher, or garbage disposer he buys. And manufacturers' claims about their products are often more fanciful than factual. For instance, a leading appliance manufacturer boasted that it had developed a quiet dishwasher and quiet garbage disposer. I inquired about details, but after six months of correspondence in which I was referred from the Chicago plant to the Louisville, Kentucky plant, and from product planner to engineer to product redesigner, no meaningful information - not even on decibel reduction, if any - was forthcoming."[31]

## ILL EFFECTS OF NOISE

### INTERFERENCE AND SENSITIVITY

"Everyday noise is assaulting American ears at an intensity approaching the level of permanent hearing damage, if indeed the danger point has not already been passed."[32] - John Mecklin

Noise is a very irritating and a very harmful form of pollution. Unwanted sound, or noise, can be distractive, disturbing and can create many ill feelings on the part of the receiver. Annoyed by a constant bombardment of noise, a worker can lose efficiency and become disinterested in his job. Accidents and absenteeism are more prevalent under conditions of constant noise. Industrial noise is a major source of our noise pollution as is highway traffic. But these sources are usually not the ones that receive the major number of complaints. Their noise level is fairly constant and the human ear gradually becomes accustomed to the noise level and subconsciously ignores it. However, it must be cautioned that simply ignoring the noise doesn't make it go away or reduce its volume or ill effects on the receiver.

"The frequency, duration, and intensity of the noise exposure affects the social aspects of noise. For example, a family who lives on a jet flight pattern to an airport reacts quite differently to the sonic booms than does a family who hears only an occasional sonic boom. This personal reaction is illustrated by the increase in the number of law suits against the airline companies.

The degrees of interference with activities of daily living depend both on the type of noise and the chosen activity of the individuals involved.

If a person is trying to sleep, a noisy party in a neighbor's yard in the early morning hours is extremely annoying, and if this activity occurs frequently, it may cause the sleepless neighbor to call the police.

An individual's reaction to noise varies from complete acceptance to extreme annoyance. Much of an individual's attitude depends upon whether he considers the noise to be necessary to an particular activity (e.g. engine noise from a lawn mower), the location of the noise (e.g. construction in a commercial area as opposed to construction near a residential area), and his own sensitivity to noise (e.g. a nervous or fearful person is more liable than a calm individual to be irritated by noise)."[33]

"Road traffic, diesel engines and the upward trend in speed and weight of automobiles have helped increase the level of noise, but jet engines are probably the biggest cause of stress to the most people. And we are developing louder and higher pitched noises. Police, fire and ambulance sirens are so shrill that their whine cuts through the din of everyday traffic; and many new and different industrial plant processes are being developed which will emit strong sound energy in the infra and ultra-sonic frequency ranges. In the Hudson Tube Terminal in New York City, when the PATH train comes in to a screeching stop, the sreech of the wheels is so loud that strong men standing on the platform stuff their fingers in their ears and women have been seen to cry. It is literally that loud and painful."[34] People are starting to go deaf at 25 in New York while in Africa and other less industrialized nations of the world, deafness does not really even start to begin until the age of 70 or over.

If city noise continues to rise as it is presently rising - by one decibel a year - everyone will be stone deaf by the year 2000. The Surgeon

General says that between 6 and 16 million Americans today are going deaf from occupational noise. For example, one New York City bank has suffered such employee turnover in its noisy check-tabulating room that it has taken to hiring deaf people to work in the room.[35] While this is a break for a few deaf people, it is hardly a solution for the problem.

The degree of irritation or distraction from tasks is presumably dependent on the frame of mind, on the nature of the tasks, and the nature of the sound, including the amount of meaningful distraction it contains.

And yet with all the ear-splitting noise that we produce today, the future looks worse unless we as a nation do something about the noise problem. Many individuals are starting to act now, and some measures calling for noise abatement have been passed, but little has really been accomplished so far. The head of New York's "Citizens for a Quieter City", Robert Alex Baron says that:

"Tomorrow's noise will be more disturbing and crueler than today's, for two reasons. First, we are increasing the number of noise sources and saturating the entire environment. Second, we are becoming sensitized to noise."[36]

We are becoming more sensitized or aware of the noise pollution problem. As the quiet places in this country rapidly vanish under the roar of onrushing progress and technology we are slowly realizing the dilemma that we are facing. Read the next section carefully and absorb some of the grim details of how noise is tearing down our bodies and our minds.

PHYSIOLOGICAL EFFECTS:

Hearing Loss:

The most obvious and well-known detrimental effect of noise pollution is hearing loss. The United States is the noisiest country in the world, and

we have the highest incidence of hearing loss. Our affluence has "blessed" us with many cars and trucks, trains and airplanes, and we work under deafening conditions in factories and offices. However, many people choose to ignore noise instead of doing something about it. A "tough-guy syndrome" has developed among many industrial workers and is resulting not in status, but in permanent hearing losses.

"A noise-induced hearing loss initially damages the sensitive hair cells in the organ of Corti, causing a loss of acuity at 4000 cps. Since a person's ability to hear conversational speech is not affected, the hearing loss usually goes undetected in this temporary or transient stage. However, when the loss also involves the lower frequencies, it is more severe in degree and affects the person's ability to understand speech; it has become a permanent hearing loss. Obviously, these two types of hearing loss have many gradations between them, with the former tending to be replaced by the latter if not recognized and treated. A noise-induced hearing loss generally affects both ears in persons under forty years of age. Some individuals seem more sensitive to loud sounds, and therefore are more susceptible to this type of hearing impairment."[37]

Hearing loss comes rarely from a sudden loud boom. The vast majority of hearing loss cases result from a constant exposure of days, months, and years. Any prolonged exposure to above 85 dB could result in permanent hearing loss and many of the industries in this country have noise levels reading even above 85 dB. Construction sites are especially noisy where readings well over 100 dB have often been recorded.

"Americans often seem to react to noise as if it were a narcotic, as though nature were compelling us to accept it, even savor it, rather than

engage in a hapless struggle. Researchers have found, for example, that workers in noisy jobs often refuse to wear ear plugs because they are proud of their ability to 'take it'. In truth, this kind of tough-guy syndrome seems to be a subconscious device for sublimating discomfort. Psychologists think a similar narcotic effect may help explain why teen-agers sit for hours in rock joints, overwhelmed by 'music' (as high as 130 dBA) that blots out all else in the world, and like marijuana, enables them to escape temporarily from reality."[38]

Dr. Howard Hardy of Armour Foods said: "Many household devices, including vacuum clearners, kitchen mixers, air conditioners, refrigerators and flourescent lights, make quite a lot of noise. Each of these devices appears to have its own maximum acceptable noise level. In other words, people will accept noise levels of 90 dB from a vacuum cleaner but will complain if a flourescent light goes much higher than 40 dB. This presents a rather large sliding acceptance scale. In contrast to the acceptance of the Chicago Transit Authority at about 85 dB are the great complaints made about the 30 dB noise level produced by a power plant in Miami, Florida. Similarly people accept truck noise to a considerable extent, and yet when the very big and noisy trucks from the West Coast invaded the Middle West, many complaints were received."[39]

"Perhaps the best illustration of harmful noise tolerance by people is the enjoyment derived from discotheques. Various researchers have surveyed noise levels in discotheques and compared their findings with the State of California's Damage Risk Criteria. Because discotheques are recreational, this noise level is well tolerated. However, if the same noise levels were presented in an industrial setting, the employees would have a legitimate complaint for management to resolve."[40]

"Of particular medical interest to young people is a recent survey by Dr. David Lipscomb, in which the hearing of 3,000 public school children in Knoxville, Tennessee was tested. The students were sixth, ninth and twelfth graders in Knoxville schools and 1,680 incoming freshmen at the University of Tennessee. His results show that:

(1) more hearing losses were found in the older groups of students

(2) more males than females had hearing losses."[41]

The results were as follows:

| | |
|---|---|
| 6th graders | 3.8% |
| 9th graders | 11.0% |
| 12th graders | 12.6% |
| college freshmen | 34.8% |

Dr. Lipscomb stated that:

"We were shocked to find that the hearing of many of these students had already deteriorated to a level of the average 65 year old person."[42]

Conclusions drawn about the results were:

"Males traditionally have interest in firearms, motorcycles, dance bands, and power boats or snowmobiles, which may be responsible for their greater incidence of hearing impairment. In the past, such large numbers of high frequency hearing losses have not been detected in these age groups."[43] This result no doubt stems not only from the exposure of young people to rock combos and bands with their loud amplifiers, but also to the general increase in the noise level in every state in the union. "One wag has suggested that labels should be used on records saying, '*Warning: Modern Music May Be Hazardous to Your Hearing.*' Unfortunately, the slogan would be true, but not only for modern music. It applies to any loud music, and even classical music gets loud."[44]

To quiet all those doubters who contend that our culture and society does not necessarily induce hearing loss, there is a study done by Dr. Samuel Rosen, a leading Manhattan otolaryngolist. In his book, This Vital Air, This Vital Water, Thomas Aylesworth records the study. It reads:

"There are quiet places on earth, but we have to travel far to reach them. A tribe of Africans, called the Maban, live in a quiet zone of southeastern Sudan. The background noise in their communities is measured at about 1/10 of the sound made by a running electric refrigerator. They have no manufacturing plants, no automobiles--no cattle or other animals except chickens. What little noise they do have is muffled by the vegetation, since there is no concrete highway or other sound-reflecting surface nearby.

Dr. Samuel Rosen, a research physician, has made three trips to study these people, and he has discovered some amazing things about the effects of noise on a human. He found, for example, that more than half of the Mabans who are from seventy to seventy-nine years of age can hear sounds only two percent of the people in our culture in that age range can hear. And not only that, but the average Maban in his seventies can hear as well as the average New Yorker in his twenties. Dr. Rosen concluded that noise pollution is a serious cause of hearing loss."[45]

The conclusions to be drawn from this study are obvious. Our technical "civilized" society with its machines and industries definitely affect the hearing of our population. Hearing loss is not a necessary evil of advancing age, but is brought about by a lifelong exposure to loud noises throughout every walk of life in the United States.

Other Resulting Bodily Damages

Many people erroneously believe that hearing loss is the only physically damaging effect of noise. Many medical and scientific studies have shown that noise, especially loud, constant noise, is sometimes a contributor to bodily malfunctions and is often the prime contributor, especially in mental disorders. Noise can cause ill effects of short and long durations and in many cases unless the situation is somehow remedied, the effects can spread and grow into complicated and irreversible disorders.

Noise has been proven to be one of the contributing factors to all of the following:

1. hearing loss
2. dizziness
3. nausea
4. difficulty in breathing
5. coordination of limbs breaking down
6. multiple psychological disorders
7. nervous disorders
8. depression
9. psychosomatic diseases
10. peptic ulcers
11. hypertension
12. accidents
13. blood vessels constricting
14. skin to peel
15. muscles to tense
16. adrenal hormone injected into blood
17. heart disorders
18. high blood pressure
19. allergies
20. spinal meningitis
21. impaired vision
22. excess sweating
23. fatigue
24. headaches
25. tinnitus
26. temper tantrums
27. loss of sleep
28. death in lower animals

As you can see, the ill effects that noise has been directly or indirectly related to are widespread and encompass physiological and psychological disorders. A later section will deal with the psychological or mental stress caused by noise. This section attempts to explain the various physiological disorders reculting from exposure to noise.

Russian architect Constantin Stramentov said:

"So harmful is noise that it can sometimes kill. The hooting of a car symbolizes this mortal danger. The noise made by a motor horn two yards away is estimated at 85 - 100 phons. It has been established that man's visual reaction drops by twenty-five percent when the noise level rises to 90 phons. The possible consequences of this needs no elaboration."[46]

This article is a good example of how noise can cause accidents (No. 12 on the list). In many industrial and construction situations the level of noise is so high that shouts of warning could never be heard. Working under such noisy conditions is doubly dangerous as one is subjected to not only bodily and mental harm from the sound vibrations but also from possible accidents that would most likely never occur in quieter surroundings. Here is a tragic accident that resulted in death of two innocent people;

"When you hear that helicopter noise is not different from any other city noise, think of the two people who were killed when Senator Robert Kennedy's funeral train was passing through Elizabeth, New Jersey--killed because the noise from the low-flying Secret Service and news-media helicopters masked out the warning horn blasts of the approaching train that hit them."[47]

Noise further degrades our society in many other ways. Besides destroying the peace and relaxation of millions of Americans each day, such disgusting events as the following can and do often result because of the noise of our society.

"In 1968, human tigers could murder in the city jungle and not be heard. On January 18 of that year, a middle-aged jeweler, held up in his shop in the heart of Times Square was shot, not once, not twice, but four times without any of the scores of pedestrians hearing a sound. The shots

were drowned out by the noise of compressed air hammers and other equipment at construction sites nearby. The two holdup men escaped."[48]

Almost everyone has experienced headaches resulting from noise. Whether it resulted from the noise of office machines, construction equipment or children playing is usually irrelevant. Noise has been related to malfunctions or abnormal constrictions in muscles and blood vessels. It has been related to heart disorders, high blood pressure, nervous tension, dizziness, nausea and fatigue. One can easily see the connection between these disorders and noise. But what about No. 4 - difficulty in breathing - and No. 21 - impaired vision? Like many other malfunctions these two result from abnormal and excessive vibration of the body parts. Vibration that is caused by the strong and constant sound waves emitted by the source of noise pollution. And yet there is no real escape from noise pollution. You cannot turn it out. Even while you are sleeping, noise is affecting you! Unlike your eyes, your ears have no lids to shut. Sound waves are constantly bombarding your ears. This often results in those sudden awakenings in the middle of the night for no apparent reason. Consciously you heard nothing, but the sound waves were so strong as to excite your brain to consciousness.

If you're one of those poor souls who are light sleepers, noise can have an even greater effect on you through causing loss of sleep. The following is a report on such situations;

'Many things happen to persons deprived of sleep. Dr. Keitman found that the most prominent effect is extreme muscular weariness. He wrote, 'Among other features of behavior in sleep deprivation are irritability to the point of irascibility in normally even-tempered subjects, and a mental disorganization, leading to dreaming while awake, hallucinations and

automatic behavior, occasionally bordering on temporary insanity.' It is easy to understand why the third degree method of continuous interrogation for many hours will make a person sign a 'confession', even if he is innocent of the crime he is accused of having committed. He wants to be permitted to sleep, and he fails to realize the seriousness of his self-incrimination."[49]

These few examples are samples of events that happen daily throughout the United States. They are events that could have been prevented by lowering the noise level. And the accidents and suffering because of noise are excessively tragic because the noise does not have to be. It can be controlled and eliminated.

PSYCHOLOGICAL EFFECTS:

Mental Illness:

One of the most damaging effects of noise pollution is the effect it has on the human brain. Mental illness is running rampant in the United States today and both scientists and laymen agree that noise is a prime cause. John Mecklin states in the article, "It's Time to Turn Down All That Noise,"

"In communities all over the world, the daily harassment of needless noise provokes unknown millions to the verge of violence or emotional breakdown."[50]

The everyday stress and strain of living in our "civilized" society takes it's toll of minds each day. Noise serves sometimes to start the process of mental distress and sometimes it just compounds an already existent problem. How many people have "lost control" or "blown their cool" because an excessive noise was bothering them? I think everyone has been guilty of that sometime in their lives. These temper tantrums or composure

collapses are steps along the road to many mental illnesses.

Behavior is often governed by the noise climate in a situation. A normally even-tempered person can become very unreasonable and violent in the grip of an irritating noise. There is a general agreement that most people are bothered by noise and that any particular noise will probably bother someone.[51] And the louder the noise the more irritating or annoying it is to more people.

In terms of annoyance, the degree of annoyance is often dependent upon the mood of the receiver. If a person is happy or expectant of the noise, it will not likely annoy him as much. But if a person is already irritable or in a state of mental illness or pain, loud noise will most likely annoy him very much. It's a well-known fact that sick patients get well faster in a quiet surrounding. They can relax more and sleep better and under such conditions their bodies can function better and heal themselves faster.

Noise distresses and depresses us. It affects our thoughts, ruins our concentration and destroys our relaxation. It's a small wonder that our national parks are so crowded with people. People living in urban areas go to national parks seeking the beauty and peaceful quiet they offer. Unfortunately, too many people are going and many of the areas are anything but havens of quiet. It's all too obvious - people are noisy, cars and trucks are noisy and our lifestyle is noisy. It's no wonder our incidence of mental illness is so high. In many other countries around the world, the mental illness rate is lower. It seems that the less industrialized, less noisy countries have much lower mental illness rates than the more "advanced" nations of the world.

Belligerence:

Noise has sometimes caused people to mentally "go over the edge". Studies have proved that noise excites people to unnatural belligerence and causes them to commit acts which they would probably never do under less noisy conditions. The following incidents are true and need no explanation.

"While few sociologists would posit a direct connection between the continuous bombardment and the growing incidence of violence in our society, a number of cases seem to suggest that noise is at least a factor in people's overreactions to the events around them. Fathers have been know to physically attack their children over loudness of music, especially if it is rock and roll music. People have committed murder or attempted suicide when the noise around them became intolerable for them.

A now famous case-in-point is the slaying in Bronx, New York, of the young son of a prominent black leader, who was shot as he ran and played with his companions. There were no political implications in the tragedy. The murderer, a black night worker, confessed that he had 'lost control of himself' when the noise of the children playing disturbed his sleep.

In Florence, Italy, another worker penned a distraught note complaining of the 'unbearable noise' from the street outside his apartment then attempted to hang himself."[52]

> "Blames Suicide Bid on 11 Noisy Children
>
> Palermo, Italy, Oct. 27 (UPI)
>
> Biovanni Gatto, 44, attempted suicide with an overdose of drugs today because his 11 children made too much noise while he was watching the Olympic games on television, police said. Gatto was taken to a hospital where doctors pumped his stomach and placed him under observation."[53]

"Noise Of Party Leads To Slaying

Gene F. Avant, 37, of 6216 Dorchester Ave., was killed by four blasts from a shotgun last night during a drinking party in an apartment at 6619 Blackstone Ave. Other guests accused R_____L. N_____, 37, occupant of another apartment in the building who objected to the noise. N_____was to appear in Felony court today on a murder charge."[54]

"Other factors may have been at work on these people such as a propensity to violence or self-destruction in the first place, but the growing body of evidence points to noise as a definite element in trouble stemming from irritability and frustration in both urban and surburban or rural dwellers."[55]

Such incidents of murder and suicide are growing in number across the globe. While murders due to noise are less common than suicides the number and rate is alarming. Theodore Berland states in his book, The Fight For Quiet that:

"Not only might the rate of noise deafness, heart disease, and nervous breakdowns increase by then, but also the rate of suicides. They have already been climbing. In the U. S. more people kill themselves (annual suicides: 20,700, or 10.5 per 100,000 population) than kill others (annual murders: 13,100 or 6.6 per 100,000). Suicide rates have increased in recent years in America, as they have in many advanced, noisy countries, Sweden, Australia, Belgium, England and Wales, Poland and Canada. International statistics show that more than 76,000 human beings - most of whom live in noisy surroundings - take their lives every year. Who is to say that the unbearable noises of our society does not in some major way help convince many emotionally afflicted that this life is simply too unbearable?"[56]

It is evident that noise is not only destroying our relaxation, but also is destroying our minds, our sanity and causing many people to destroy themselves. Noise is a very harmful and dangerous pollution, yet it is a very subtle killer. The world must learn to know this enemy and bring it under control. But as Pogo so aptly stated - "We have met the enemy and he is us". We can stop noise pollution. We, all people, produce it and we can and must eliminate it in order to preserve our sanity and our very lives.

SONIC BOOMS:

Explanation of Sonic Booms:

"According to the World Health Organization, health is prejudiced by interference with peace of mind, privacy, the pursuit of work or pleasure or with the basic requirement of a natural and undisturbed nightly sleep. Noise pollution is still a growing pollution. The tremendous number of cars, trucks and trains, together with all the industrial noise creates quite a racket in this country. Yet, a new type of noise pollution - sonic boom - is threatening to dwarf all other forms as the major cause of damage, complaint and overall national dissent."[57]

Sonic boom is truly an irritating form of noise pollution. With more and more jets, commercial and military, flying at supersonic speeds, the problem is getting increasingly worse. Many people do not understand sonic boom although they are bothered by it extensively. This section will attempt to explain what sonic boom is and some of the physical and psychological damages it causes around the world.

"The sonic boom is a sudden pressure disturbance, shock wave, in air. A boom is produced because the air in front of a plane flying at supersonic speed has not had enough time to get out of the way in normal manner.

When a subsonic plane flies along, the air ahead of the plane moves aside smoothly with negligible changes in pressure - and moves back in behind the plane again. There is no great compression, and no energetic wave is produced.

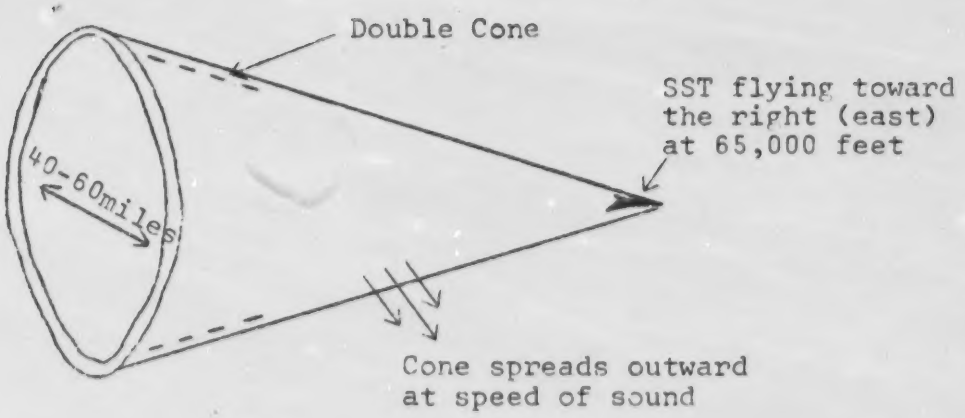
But for a supersonic flight the situation is utterly different. Because the plane is traveling at a speed faster than sound can travel in air, the air in front of the plane receives no advance 'push' as the plane approaches. Each cubic inch of air remains motionless until the very last second: not until the plane has approached within a half-inch does the air begin to move out of the way. It must then move out of the way in a few millionths of a second.

Its motion is extremely energetic. There is extreme local compression and heating, and a highly energetic shock wave spreads out in a cone. The energy in the shockwave from the plane as a whole is enormous; the power radiated outward in this wave amounts to 10,000 to 50,000 horsepower comparable to the power required of an ocean liner such as the Queen Elizabeth.

The shock wave travels far, jolting everything it strikes. It continually spreads outward until the diameter is about 40 to 60 miles, beyond which the pressure rise is too small to be significant.

The bang-zone is the portion of the earth's surface struck by the boom from a supersonic plane. The bang-zone is as long as the supersonic flight path itself; if a plane flew at supersonic speed for 2,000 miles, then the bang-zone would be 2,000 miles long. The intensity of the boom depends on many factors such as atmospheric conditions, altitude of plane, speed of plane, length of plane and others. The proposed SST (Supersonic

transport) if finally built commercially would be the worst noise pollutant imaginable. Its sonic boom would be greater and more damaging than any we've experienced yet and a whole fleet of such super jets would have disasterous results in property and human damages."[58]




Conical Shock Wave

The following events were results of supersonic flights over the world. As you will see, the effects are extremely harmful to animals, geological formations and humans. And all of the incidents are bad. Not one good thing has ever developed out of a sonic boom. However, the world is plagued with them and their number seems to be on the upswing as 'progress' moves forward at a faster and faster pace.

"Oklahoma City - In the mid-1950's a military plane flew low over the Will Rogers Terminal at the Oklahoma City Airport and delivered a sonic boom that caused $500,000 damage.

Colorado Springs - On May 31, 1968, an F-105 plane flew at supersonic speed 500 feet above the Air Force Academy at Colorado Springs, Colorado. The sonic boom broke $50,000 worth of windows and showered broken glass onto persons attending graduation cermonies. Fifteen persons were injured.

In 1967 in Mauren, France, a sonic boom caused partial collapse of a barn, killing three persons. In southwest Germany, sonic boom from jet fighters necessitated the closing of the 18th century Abbey Church at Neresheim. The sonic booms seriously damaged timbers in the roof, which is now in danger of collapse. In Switzerland, sonic booms have triggered avalanches."[59] And right here in the United States, many of our natural monuments are in serious danger of damage or collapse as a result of sonic booms. The carvings on Mt. Rushmore have been chipped and cracked from sonic booms as have many monuments in many national parks. An overhanging rock, dislodged in the wake of sonic boom sock waves, demolished a 1,000 year old Indian ruin in Canyon de Chelly National Monument in Arizona. At Bryce Canyon National Park, Utah, 15 tons of dirt fell from a spectacular geological formation near the bottom of Navajo Loop Trail after 3 sharp sonic booms. In Arches National Monument

in Utah, the world's largest natural stone bridge, spanning 300 feet, has been cracked and jarred by sonic blasts. Every time a jet flies over, the park rangers run out and see if it is still standing. These few disasters and impending disasters are only just a few of the many all over this country and the world as a result of the sonic booms.

Aside from the damage done to natural settings and despite the damage in terms of cracked and shattered windows, cracked plaster, masonry, cracked objects of art, and fragile antiques, vibrating shelves and tumbling dishes, vases, and glasses falling and breaking, the rock slides and avalanches, there is the worldwide problem of annoyance and ill effects to humans. Many tests have been run with supersonic jets flying repeatedly over large cities in the United States. All have resulted in massive property damage, annoyance and suits against the Air Force ranging into the millions of dollars.

"The main reason people hate sonic booms is because of 'startle effect'. It has been known for decades that a very sudden, loud, unexpected noise produces a set of symptoms, or behaviors, called the startle syndrome. Typically, the syndrome includes hunching the shoulders, pulling the head forward and downward and increasing the rate of heartbeat. In addition the person may blink, jump, or cry out. Various stomach symptoms may result also, and there may be accompanying feelings of fear, surprise or terror.

Startle effects may result whether the noise is very loud or rather gentle, provided it is sudden and unexpected. A person reading a detective story late at night may be badly startled by the noise of an ash tray falling to the floor. A grandmother may be startled when a small child steals up behind her and says 'Boo'. No wonder that the sonic boom - violent enough to shake the entire house and break windows - is startling.

People differ greatly in their vulnerability to startle. At the one extreme, healthy well-adjusted adults busily engaged in pleasant occupations may experience little annoyance at a sudden loud sound. Such persons may enjoy the sound of gunfire or a loud clap of thunder. At the other extreme are elderly persons with critical heart conditions, such that even a moderately intense 'bang' may produce spasms, acute pain, and possibly even heart failure. Other vulnerable groups include: infants and very old people, persons suffering from ulcers and insomnia, persons who are very unhappy, irritated, worried or afraid, persons with mental diseases, persons in great pain or persons already ill."[60]

But the sonic booms do not only affect the human animal and the abiotic surroundings of the human. They also effect almost every other form of animal in this world. There have already been incidents in which sonic booms caused cows, horses, pigs and chickens to panic. "In Switzerland a herd of prize cattle stampeded over a cliff when frightened by a sonic boom, and it is also reported that in France a horse was startled by a boom and ran away, throwing and killing his rider."[61]

"Mink are especially vulnerable. In 1966 sonic booms from Air Force F-101 jets resulted in the death of approximately 200 baby mink on a farm in Minnesota. A farmer in Minnesota was paid $50 because booms caused his chickens to panic and suffocate against a wall.

Sonic booms may have disastrous effects on colonies of birds that nest on cliffs - because booms make the birds fly off so impetuously that they knock their eggs out of the nest and the eggs roll or fall and are soon broken. Likewise, eggs can be knocked out of nests in trees. Mass breaking of eggs after sudden loud noises is already well known. And scientists are still working on discovering possible ill effects of sonic booms on fish and marine life."[62]

## ACOUSTICS AND ACTION

### INTRODUCTION TO ACOUSTICS AND ACTION:

Perhaps the biggest crime of noise pollution is that it does not have to exist. Noise pollution is by no means a "necessary evil" of progress and industry. Within the limits of our present technology we can design products and systems which will not pollute our environment with the bangs, rumbles, and roars of noise.

Despite increasing noise and an increasing level of general concern, very little is being done to curb noise. A main cause of this situation is the general ignorance of the fact that noise can be eliminated. The majority of people detest noise but evidently believe that it is necessary and try to ignore it. It's a pity that people do not try to do any more about noise because it is so irritating and harmful. Scores of people and many world leaders have spoken out against noise pollution but little has been accomplished in the fight against it.

"'Let avoidable noise be avoided,' said the late Pope Pius XII in a 1956 appeal from the Vatican. 'Silence is beneficial not only to sanity, nervous equilibrium, and intellectual labor, but also helps man live a life that reaches to the depths and to the heights.....It is in silence that God's mysterious voice is best heard.'"[63]

The concluding sections of this report attempt to outline what an individual can do, what industries have or must do and how the city, state, and federal governments must promote and enforce regulations to curb noise pollution.

COMBATING NOISE:

Famous People Fight Back:

As stated in the first section noise pollution has been in existence for a long, long time. Over the years many people, several of them famous, have combated noise in their own personal ways. The following articles are a few ways some noise-hating people have solved their noise problems.

"As Arthur Schopenhauer wrote, '....noise is a torture to intellectual people.'

The biographies of some of the world's intellectuals prove Schopenhauer's thesis: noise so disturbed them that they took extreme measures to assure their concentrating in silence. French novelist Marcel Proust (1871-1922) hermetically sealed his studio windows against noise (and germs). American poetress Amy Lowell (1874-1925) so disliked noise that she slept by day and worked by night. When she went to the theater she bought tickets to the seats on each side of her and left them empty; when staying in a hotel she took the room above hers to assure its being empty to prevent the noise of conversation and of footsteps above her head. Railroad tycoon Edward Averell Harriman (1848-1909), father of Ambassador William Averell Harriman, so hated noise that he had a double door built to keep out noise from his bedroom in New York.

Noah Webster (1758-1843) compiled his first dictionary at home with 9 children running about. He did it by working in his second floor study which he had especially designed with foot-thick walls lined with cork."[64]

"George Bernard Shaw entered a posh London restaurant, took a seat, and was confronted by the waiter. 'While you are eating, sir, the orchestra will play anything you like. What would you like them to play?' Shaw's reply? 'Dominoes'."[65]

Perhaps you aren't as bold as some of these people. But you can do a lot to cut down on noise in your own surroundings, especially around your home. And you can bring suits against companies if you feel that your job has caused a hearing loss. Many others have. Here is a list of suits concerning hearing losses in just a few American cities:

> "Atlanta - 73 suits pending for a total of $5 million;
> Memphis - 20 suits pending, aggregating $2 million;
> New York - a suit filed by 808 plaintiffs against 39 airlines and the Port of New York Authority, totaling $1 million;
> Seattle - 200 suits pending, totaling $1 million;
> Los Angeles - 38 claims, totaling $1 million.
> Other claims in Ontario and San Francisco, California, Dallas, Denver, Houston, Jackson, Oklahoma City, Phoenix, Omaha, Portland, Ore. San Antonia, Spokane and Tampa."[66]

Things You Can Do To Combat Noise:

Around the yard and inside the house there are several methods of screening noise out or eliminating it. Sound barriers are more effective when placed either near the source of noise (i.e. street) or near the hearer. The more reflective a surface is, the less sound emitted. A thick, stone wall is about the best reflector. Fences of trees are thought to be good reflectors but they are not as efficient as stone walls. A great density and height must be achieved in planting trees for this purpose or the noise will simply flow through the branches.[67] However, there is a lot of psychology in how we react to noise. Therefore, rows of fences and shrubs do have a function. Basically they promote the "I don't see you so you're not there" law.

For the more imaginative and affluent family, a series of two or more small fountains or an artificial waterfall are excellent masking sounds. The sound of flowing water is almost universally soothing and well-liked.

And by all means, the outdoor living area (i.e. patio, pool, etc.) should be located behind the house, away from the street and the noise.

Perhaps the easiest and more efficient method of cutting down useless noise is by cutting down the noise that each one of us makes. Whether it's turning down your T.V., radio, stereo or kids, it can be done without any expense. Your neighbors will love you for it and so will your own body. Consideration for others should always be taken by everyone when it comes to mowing grass, tuning your car or riding your motorcycle. Some folks like to sleep on Saturday mornings so have a little consideration for your neighbor and don't start mowing the yard at 6:30 Saturday morning. And the next time you plan or are engaged in a loud party remember the incident in Chicago (page 36)! It could happen to you! Loud noises late at night have disastrous effects sometimes.

Inside the home noise can be cut to an absolute minimum. Porous materials absorb sound better and keep noises from reverberating over your house. Quilted fabrics, woven blinds, wood paneling, vinyl tile, draperies and carpets insulate well. Acoustical ceiling tile and double windows on the street side of the house will keep out many noises also. Of course, the main sources of noise inside the house are children, T.V. and radio plus all your electrical kitchen appliances. Tuning down these will help cut down the noise level in your home too. Sometimes it helps to provide a constant though subdued background sound such as a quiet fan or soft music. This sould will act as a masking sound to cover up the many annoying noises. The same principle is presently being used in countless grocery, and department stores and restaurants.

CONTROLLING NOISE IN INDUSTRIAL SETTINGS:

By Laws:

Industry is the prime source of noise pollution. The factories themselves are not so much the polluters as the products which they produce. Heavy machinery and all types of transportation vehicles from cars to planes are terrible polluters of the quiet. Industry has been active in curbing some of its noise and compensating workers but they still have a long, long way to go before effective measures are widespread.

"In 1908 the first Workman's Compensation Law was written, utilizing the wage loss concept. The New York Court of Appeals in 1945 for the first time awarded damages to a claimant who had not lost time from his job. (Slawinski vs. J. B. Williams Co.)

A decade ago, about 6 million workers labored under extremely noisy conditions. Today, the number is estimated at 16.5 million. Because of the increasing recognition of noise pollution as a health hazard, potential damage suits could result in bankruptcy for many industries. This is one reason for many industries initiating hearing conservation and ear protection measures."[68] Many devices have been introduced for protection, but for various reasons many of the systems or protection devices have not been used. For example, one author noted that while on a tour of a steel plant he saw the ear protection headsets lying near the workers. After several futile attempts at hollering over the tremendous noise to them, he finally gained their attention. Upon asking them why they were not wearing the protectors he found out that they considered it a test of manhood to not wear them. Anyone who did was considered a "sissy".

"The Veterans Administration is spending about $8 million a year on the claims of some 5,000 servicemen whose hearing has been damaged by gunfire in training or combat."[69]

"The WHO estimates that industrial noise alone costs the U.S.A. today more than $4 billion annually - in accidents, absenteeism, inefficiency, and compensation claims. The human costs in sleepless nights, family squabbles, and mental illness are beyond measure, but they surely must be enormous."[70]

"In 1965, 35 states had statutes where a noise-induced hearing loss was compensable. The Walsh-Healy Contracts Act of 1968 states that any firm with government contracts of $10,000 or more must limit noise in the working environment to 90 decibels.

Current legislation consists of a measure passed by the House of Representatives directing the Federal Aviation Administration to set and enforce standards for aircraft noise abatement. This measure is now before the Senate. The suits against public airport owners and operators have been largely unsuccessful, because (1) public necessity and convenience usually outweigh private or individual interest, and (2) the Federal Government has Preempted the field of air traffic control below as well as above 1000 feet from the ground. The preliminary guidance for insulating existing houses with respect to aircraft noise has been published by the Department of Housing and Urban Development.

The Occupational Safety and Health Act furthered control of noise on an industrial site to include external as well as internal maximum noise levels. To summarize, legal aspects of noise pollution consist of (1) defining the problem and obtaining meaningful legislation on the Federal, state, and local levels, and (2) protecting the individual's rights to maintain 'normal hearing' or to receive compensation for a noise-induced hearing loss."[71]

Thelma S. Graeb in her "Noise Pollution Module" states that "environmental control will necessarily come through reducing the amount of noise produced by the source or producer. This could be accomplished in several ways such as careful acoustical design of new machines, proper upkeep and repair of equipment, mufflers on exhaust mechanisms and changes in methods of processing. Control of noise transmission reduces overall noise level in a general work area, but has little effect on noise level at the source. These ends could be met by increasing the distance between the work area and the source of the noise, constructing barriers between the work area and the source of noise, sound-treating work areas to reduce reverberation or by placing equipment on vibration mounts.

Operating procedures could be improved through changing job schedules, rotating personnel and enclosing remote control stations. These methods would benefit workers' health and industrial efficiency and trouble-shooting."[72]

"In an acoustically untreated room (where the boundary surfaces are finished in hard, sound-reflecting surfaces) multiple sound reflections persist audibly for prolonged periods of time, even, in some instances, as long as 10 to 15 seconds. In such a room, also, the sound levels will be high.

The fundamental purpose of acoustical materials is to reduce either the average sound-pressure level or the reverberation time in a room, or both. Acoustical materials are generally applied to wall and ceiling surfaces and occasionally are suspended freely in the room. In spaces where speech and music listening are important, a certain prolongation of sound is desirable. The application of acoustical materials in these instances is referred to as 'reverberation control'. In spaces where noise may be a problem any prolongation of sound is generally undesirable. The application of acoustical materials in these instances is referred to as 'noise

control'. Thus, the designer must consider the use to which the space will be put and the amount of sound absorption required to meet satisfactorily the varying degree of room performance requirements."[73]

"Commonly, the term 'acoustical materials' is applied only to those materials that are capable of absorbing an appreciable high percentage of sound incident on the surfaces. While there is no specified lower limit of percentage of sound absorption which a material must have to qualify as 'acoustical' it is generally assumed to be about 20%. By contrast, ordinary building materials, such as glass, plaster, concrete, etc. have a sound absorption generally not in excess of 5 to 10% and are more often in the region of 1 to 5%"[74]

"The most common measurement for the price of something is dollars. There have been few attempts to measure what either the individual or society is paying for excessive noise. We must face the fact that it is probably cheaper - in direct dollars - to make noise than to curb it. This is why we must recognize a price in health and the intagibles...."[75]

"Given incentive, the human mind is inventive enough to design for quiet. The public does not have to spell out how quiet. It does have to communicate to government and to the manufacturer that it wants a quieter environment. Then it would become corporate policy not to make, buy, or sell equipment above a certain noise level. Engineering and acoustical expertise plus common sense would achieve a comfortable, non-destructive environment."[76]

"The most effective and possibly the least expensive method of noise abatement (as far as society is concerned) is to design machines that generate

and radiate little noise. Engineers can be trained to determine if a given noise can be reduced at its source. Machine noise is not natural. According to one consulting engineer, 'Noise is a form of pollution that is not necessarily inherent in the design of larger, more powerful systems and equipment. It is not necessary for design engineers to accept increased noise and vibration as an unavoidable accompaniment to the power, capacity, and efficiency of industrial machinery.'"[77]

"The design of the factory is crucial to an effective noise-control program. The various departments, for example, need to be arranged according to the intensity of noise they produce. The noisiest department or workshop must be situated so that it is surrounded by massive noise-insulating walls. Screening devices can also be used to confine the sound.

When the noise level within a confined area is too high to allow workers into the area even with the use of personal protection devices, the operation should be automated. An automated operation can be supervised from observation posts, that is, from remote-control stations where the workers are adequately protected. A remote-control post can receive information via closed-circuit television, or it can be highly insulated to completely protect the worker. In either case, the production procedures are handled by mechanical devices under man or computer control.

Proper maintenance is another important consideration in an anti-noise campaign. Noise often results from worn bearings and worn parts that fit loosely or have excessive play in them. Proper lubrication of moving parts are key means of reducing noise in most operations. In most cases, the production of excessive noise means a rather inefficient operation. Concern for noise control may lead to more efficient ways of operating a business or industrial process."[78]

"The noise at a building site is not only dangerous to the construction worker but also to people who are constantly in the vicinity. Residents and those who spend the day working in the city are continually exposed to unwarranted levels of noise. Noise does contribute to changes in and impairment of the hearing mechanism. And there is a definite relationship between loss of hearing and length of exposure. Without doubt, we all suffer as a result of high noise levels.

Operators of construction vehicles are definitely exposed to hazardous levels of noise. An effective means to protect the operator is to increase the distance between the cab and the noise source. In addition, he might be enclosed in a tight cab to block out the noise produced by the machine. Personal protective devices, such as ear plugs and ear muffs, can also be used. An exhaust stack is a major source of noise. Specially designed mufflers fitted to the exhaust tend to reduce the noise emitted. In addition, there is a real need to require manufacturers to design and to produce quieter engines."[79]

"In many industrial or military situations, it is not practical or economical to reduce the noise to levels that present neither hazards to hearing nor annoyance. In all such situations personal ear protectors are of great value and should be recommended. They are capable of reducing the noise level at the ear by 10 to 45 dB, and occasionally to 50dB, depending on their make and the sound frequency. A personal ear protector or a combination of personal ear protectors often permits the reduction of noise at the ear, if not to pleasant level, at least to a harmless one.

Ear protectors can also improve speech communication. The widespread belief that ear protectors impair hearing acuity holds true only in a quiet

environment where ear protectors are not usually necessary. At noise levels justifying their use, they not only do not impair hearing acuity but may even improve it. A possible exception is an intermittent noise with periods of silence between the burst of noise."[80]

"Traffic noise tends to be taken for granted, but it is probably the least necessary of all the annoying, nerve-racking sounds beating against us. Automobiles can be equipped with good exhaust silencers, but many are not. The desire for greater horsepower should be curtailed. Larger engines mean more energy is liberated by the vehicles; and thus, more noise cascades into the environment. Tire threads are often quite noisy. There is no need for this. Quiet threads should be produced and required on all vehicles. The road surface also contributes to traffic noise. Whenever resurfacing of city streets is undertaken, it should be done with materials that produce quiet road surfaces.

There should be acoustical tests for automobiles, trucks and buses as a regular part of a required state motor vehicle inspection. The best procedure is to measure the noise produced when a sound-level meter is held at a distance of 25 feet from the vehicle."[81] France and Great Britain have already put decibel level controls on new autos (85) and motorcycles (90). Similar regulations have also been applied in Germany and Switzerland.

"One way to attack tire whine, in his view (Christopher G. Rice), is to vary the tread pattern of the tire, so that it does not repeat itself. Also, by eliminating the smallest cuts or slits, the higher frequency whines can be eliminated. Thus, if the tire manufacturers wanted to they could produce quiet, or nearly quiet tires.

Another way to cut down the noise of cars is to modify street surfaces. How much noise a tire makes depends on the road as well as on the tire. Siren noise is only part of the problem. The other problem is the noise of the rubber on concrete, or on whatever material the road is made of. Roadway noise is also transmitted through the body of the car to the driver and passengers."[82]

As becomes evident through reading these articles noise control must come from preventive measures and not measures meant to cure. The designing of acoustically performing machines and products is necessary to curb noise in industry. The question of money and the lack of public pressure on industries has stopped most industry from attacking the problem so far. However, mounting pressure is rising and hopefully the day of noise control is well within sight. The cost will have to be shared jointly by industry and by the consumers in the form of higher prices for products. But it is a cost which we must be willing to pay for our health's sake if for no other reason. The following article describes some of the expected additional cost which would arise for producing quiet products:

"Virtually all man-made noises, whatever its source, can be suppressed. While some major problems, such as thin apartment walls and the roar of New York City's subway, would cost large sums of money to correct, many of the most irritating noises could be reduced at negligible cost. The screech of truck tires on pavement, for example, can be reduced at no extra cost or efficiency loss by redesigning the tread, and a quiet home lawn mower costs only about $15 more than the usual ear-jarring model.

Some other examples of added costs:

- a garbage truck $2,400 (on top of an original cost of $15,600)
- a small air compressor $500 (on top of an original cost of $5,300)
- and on most machinery an additional 5% atop the original costs. In some cases there is also a relatively small cost in reduced efficiency. Mass production of silenced equipment would lower costs still more."[83]

COMMUNITY NOISE:

Community Responsibility:

"In modern, industrial countries many persons must live and work in environments that contain undesired, obnoxious, or potentially harmful physical agents. Sounds are by-products of the mechanized operations that characterize modern industries.

When the ambient sounds to which a majority of the occupants of an area are exposed can be described as noise we may call the sounds community noise.

Practical experience has shown that community noise may create individual and group resentments toward a noisy operation and its operator. Sometimes when the community noise levels were high, these annoyances and resentments have been accompanied by positive, concerted action to remove the offending source. Industrial plants and other noise-producing operations have been forced to shut down."[84]

"Unlike other forms of pollution, noise comes from an infinite number of sources and cannot be cut off simply by cleaning up a few big operators such as garbage dumps. The answer, however, does not lie in brave new proclamations. Ways must be found to get at the problem through appeals to the

self-interest of business and community leaders and through governmental regulations that are realistic and easily policed."[85]

Just as the fight against noise pollution must start with each individual, it must start with each community in every state. Federal regulations are needed also, but if only federal regulations are made into law, these laws will be difficult to enforce. Local regulations and strict local enforcement of noise control laws is desperately needed. Some cities have already taken steps toward that end but their number is few. Every community, from the smallest to the largest, needs a set of noise control regulations.

John Navarra writes in his book, Our Noisy World, that "a community needs to constantly review its commercial routes. The routing of heavy vehicles through certain sections of the city should be strictly enforced. Care needs to be taken to keep commercial vehicles as far as possible from residential areas.

A more subtle way of reducing traffic noise is to study the topography and to use contours and existing features of the landscape as natural barriers to confine sound. Traffic noise enters the environment directly from the noise-producing vehicle or by reflection from a nonabsorbent surface. When a roadway, for example, is placed in a cutting, the spread of noise is sharply reduced and, at times, eliminated. An elevated roadway is another effective means of reducing sound levels since the noise is carried up and away. And then, of course, there is the possibility of mounting sound barriers on a roadway. These barriers can be functional and beautiful. But the most effective means of controlling traffic noise is to do away with the traffic."[86]

"At the present time it is not sufficient simply to have a law that calls for lower maximum noise levels for all operating aircraft. The real solution is to concentrate on the new aircraft being produced. The U. S. has certain federal requirements that must be met with respect to noise levels before a plane is certified for flight. Stricter enforcement of this regulation is the best means for attacking the problem of air traffic noise. Such action would also insure that pressure would be applied at the right stage in an aircraft's development.

Airports in the U.S., Great Britain, France, Denmark and Australia have set guidelines concerning acceptable noise levels. As a result, silencing devices have been fitted to the exhaust ports of most turbojet engines. Such devices have helped. A simple way of cutting down noise, however, is to mount the engine nacelles above the wings. This tends to prevent some of the noise from heading toward the ground. Thus, the steps that might be taken to reduce aircraft noise are: (1) manufacture aircraft designed to take off and land at steeper angles, (2) establish better noise control by building silencers into airplane engines, (3) introduce more sophisticated instruments and operating procedures and (4) mount the engines above the wings. But the key to controlling air traffic noise is to establish and enforce maximum noise levels that will be allowed in new aircraft."[87]

"Every community needs a planned anti-noise campaign. There are three broad areas that ought to be encompassed by any thoughtful plan if it is to be successful in reducing the levels of noise pollution: public health, architectural planning, and application of recent technological developments."[88]

Navarra goes on to say that "every community has a responsibility to protect the health of each of its citizens. This responsibility extends to

the physical conditions under which its citizens are employed. With this in mind, industrial working conditions need to be examined and studied to assess the effect noise has upon the workers in specific industries. Industry and the public generally must be made aware of the physical, mental, and emotional consequences produced by noise. The public health agencies of the community must be given the specific responsibility of guarding the citizenry from these dangers. Public health officials should be instructed and required to request the kind of legislation needed to accomplish those tasks.

Many towns and communities have grown up without much forethought. And the planning that has been done has not included a concern for noise pollution. Town-planning procedures must be restructed so that serious steps are taken to utilize new techinques and methods for sound control in the lay-out and design of the total community. The community, through its building code, must determine the kinds of structures that can free the inhabitants in various sections of the city from the sounds that will impinge on the buildings. The civic commitment should be to establish an environment where people can function safely, and creatively with as little discomfort as possible."[89]

Community Actions:

Just such regulations are already in existence in many European nations. Sweden and Germany have standards of noise control and sound insulation reflected in local ordinances and national building codes. Some apartments in Great Britain are rated by their noise level. In this way, a person can choose his own level of quietness. Other countries also have absolute decibel level controls in their building and manufacturing codes. We, in the U.S.A.,

could have such controls. We need them, perhaps worse than anyone else in the world because we are the noisiest country in the world.[90]

"We need a new breed of technician , says John Navarra, a human watchdog, who oversees town planning and the construction of individual homes with but one consideration - noise. His only professional commitment should be to search out and advise on ways to deaden noise and to bring silence to areas now inundated with sound.

Town planners, architects, and builders need to show more concern than they presently do for the problem. In the construction of most modern housing and most office buildings, insufficient attention is devoted to excluding noise from the outside and noise that echoes from floor to floor within the building. There is very little excuse for this lack of attention, for effective sound-proofing techniques exist."[91]

"If we are wise," Navarra contends, "the renewal of our cities will provide many opportunities for reducing noise levels by incorporating open spaces and protective screens in the design of streets and in the area around building. Walls of silence can be built around residential and industrial areas."[92]

Memphis, Tennessee is a good example of a community mobilizing for action against noise. Among the ordinances Memphis has enacted is one outlawing excessive or unnecessary noise caused by construction, radios, faulty mufflers, auto horns, loud trucks, and a host of other noise offenders. In addition to the noise ordinances, Memphis simultaneously instituted a program of education and strict enforcement procedures.

"Memphis' ordinances says, 'Yelling, shouting, hooting, whistling or singing in the public streets, particularily between the hours of 11 p.m.

and 7 a.m. or at any other time or place so as to convey or disturb the quiet, comfort or repose of persons in any hospital, dwelling, motel, or any other type of residence or of any persons in the vicinity is hereby prohibited.'"[93]

The program of education in Memphis was designed to sensitize people to the need for a reduction of the sounds that were being unleashed into the environment. Enforcement includes a gradual system of warning that alerts first offenders. Then a system of graduated fines is levied against those who continue to offend. Memphis is far ahead of most other American cities in noise control, but it does set a good example of action and means of controlling noise in the city. Hopefully, many cities will imitate and improve upon the Memphis noise abatement system and apply it to their own cities.

"The City of Chicago has various anti-noise sections in its Muncipal Code. So does Memphis, Tenn., and yet the latter and not the former is known as the Quiet City. Most of the provisions of the ordinances of both cities do not deal directly with the decibel levels, but are rather general. In Chicago, for instance, 'No person shall make, or cause, permit or allow to be made, upon a public way, or in such close proximity to the public way, any noise of any kind'....."[94]

"California has a law limiting the vehicle noise on freeways to 88 dBA, and a noise abatement commission will begin hearings aimed at producing recommendations by 1971. In New York State, indignant citizens along the roaring New England Thruway, where some 10,000 trucks create a steady din around the clock, persuaded the state legislators to fix a limit of 88 dBA on each vehicle. There have only been 63 arrests since 1965 and the maximum fine is only $10 anyway.

Despite its multitude of other problems, New York City probably has tried harder than any other big community to mount a really effective anti-noise campaign. Much of the initiative came from a group of volunteers called Citizen For A Quieter City, Inc. headed by Robert Alex Baron, 49, who was so incensed by the din of a construction project outside his Manhattan apartment that he quit his career as a Broadway play manager in 1966 to do something about it. His efforts helped coax Mayor John V. Lindsay to appoint, in 1967, a special anti-noise task force of technical experts and public-spirited citizens. These and other pressures combined to persuade the city council in 1968 to pass the first building code of any major U.S. city with an anti-noise provision. It requires that new residential buildings must be constructed to cut noise penetration by about 45 dBA, which is appreciably less strict than the codes of several European countries, but nevertheless a major stride forward."[95]

"The first and perhaps the most important course of action is to generate all possible public pressure on governments. It is no coincidence that one of the most effective anti-noise programs emerged in West Germany after the leading political parties there began including it in their election platforms. Once it becomes clear to Americans that noise is not an inescapable fact of life and that something can be done about it, and at manageable costs, the support for real action could be overwhelming."[97]

In his book, Our Noisy World, John Navarra states, "We do have the ways and means to control sound and the noise pollution of our environment. The only reason we haven't achieved noise control is that the citizens of the country at large are not committed to having the problem solved. We lack the

will to undertake the job as individuals and as government officials at all levels--city, state, or federal. The pollution will not be controlled without determination and effort from each of us. And, in an undertaking of this nature, there is going to be a dollar cost and more than a little inconvience for everyone before appropriate noise levels are established in every community throughout the land."[98] It would cost in the range of 5 to 10% extra to manufacture products that are quiet or operate quietly.

It is estimated that by the last decade of the twentieth century, four out of every five Americans will be living in cities. In some ways this is a frightening prospect when we consider the goods and services needed to flow in and out to maintain the population. The mere accumulation of such numbers of people is going to add to the problems of noise pollution in the cities.

"But the clatter will result also from all the increased activities of the people. Consider that in the U.S., today, there are 90,000 privately owned planes. By 1975, this number will increase to about 150,000. Most of these planes operate from airports in and around cities. The solution to many of these problems lies with proper city planning. But recognize that city planning has not had much success to date! Note for example--that we are moving so slowly with urban renewal that we are hardly keeping pace with the day-to-day deterioration of our cities."[99]

All of these proposals by Navarra and many others indicate the lack of concern and effective measures taken by the governments of our country, city, state and federal. Though noise pollution is only one of our many pressing problems, it is perhaps the most easily solvable. The cost is not overpowering and the knowledge of how to accomplish the task is readily available. What our country needs is for each and every citizen to learn of

the problem, its effects and how we can solve it. If each person's concern grew it would be an inevitable end that public pressure would be exerted strongly enough to force governmental officials, industries, and every individual to solve the problem. It will take pressure, concern, care, knowledge, and money. We must all be willing to sacrifice some of our time and our money. Noise pollution can be solved--it must. If we are to ever hear the sounds of birds and crickets or the melody of a song again--we must strive to put an end to unnecessary noise in this country.

"The ultimate weapon against noise - the law - which becomes a weapon in the fight for quiet only when there is enough pressure from the public to make it so. And the public is you."[100]

"Noise is not the price of progress.

Noise is not the inevitable by-product of technology.

Noise is the price you and I pay for greed and insensitivity, and our own indifference.

A quieter world is possible, if.....we don't take noise for an answer."[101]

Suggested activities

for use with

media

available at the

Environmental Education Center
13 Veterans Drive
Oteen, North Carolina
28805

PRESENTATION GUIDELINE

Title: Noise and Man: Effects and Problems

Length of Presentation: 4-5 hours

Associated Curriculum Areas: Health, Sociology, Economics, General

Grade Level: Grade 5 - Adult

Summary: Noise pollution is a growing menace to the American society today. Few people recognize the problem much less the harmful effects of noise pollution. This program attempts to create an awareness of the problem by lecture, visual and audio aids and discussion on noise pollution. Also included is a discussion of the physiological, psychological effects on people, their actions and interactions with the community at large. A discussion of legal actions, that can and have been taken to combat noise pollution, through personal and civic activities, concludes the program.

Overall Objective: To make the students aware of the physically harmful noise pollution problem we have in this country and the need and abilities to curb it.

Concepts: Noise can harm not only your hearing, but also your heart and other vital organs.
There is a serious noise pollution problem in this country.
Noise pollution can be curbed effectively today if we demand it.

Behavioral Objectives: After the presentation of this program, approximately 60% of the students involved will score substantially higher on a post-test than they did on a pre-test given to them before the program starts.
Following the presentation at least 50% of the students involved will be able to list at least 5 noises that are potentially harmful to our health and 5 that are not, i.e. nice, pleasant, soothing.

Activities: lecture, illustrated with slides and transpariences
discussions
slide presentation
tape recordings

Follow-Up Activities: post-test on noise and its effects

Resources and Materials Utilized:

cassette tape and tape recorder-player
records
slide projector
overhead projector
slides and transpariences

Bibliography:

Noise and Man. William Burns
Noise Pollution Module. Thelma Graeb

# SUGGESTED ACTIVITIES

## To Follow Filmstrip

## "NOISE AND YOU"

### Sound Travels in Waves

Purpose: To offer pupils a visual counterpart of the way sound travels.

Equipment needed: A "Slinky" toy.

Procedure: Have two pupils extend the "Slinky" across the room on the floor. Pluck the "Slinky" at one end and observe how the wave travels and bounces back. Sound travels in the same sort of waves.

### High and Low Pitch

Purpose: To demonstrate that the pitch of sound depends on the number of vibrations per second.

Equipment needed: A cloth-covered book.

Procedure: Rub your finger lightly across the book cover. Listen to the swishing sound. The sound is made by the vibration of the fingernail as it bumps up and down over each thread of the cloth.

Do this several times, moving the fingernail slowly, then faster and still faster. Notice how the sound changes. The faster the fingernail moves, the more high pitched the sound becomes. When the fingernail is moved slowly, the sound is lower pitched.

### Loudness and Softness of Sound

Purpose: To demonstrate that loudness depends on the intensity of the vibration and the distance from the sound.

Equipment needed: A ruler.

Procedure: Hold one end of the ruler on the edge of a desk or table, allowing about 8 inches to stick out over the edge. Press down hard on the free end and suddenly let go. The ruler will vibrate and make a humming sound.

Press down on the free end again, but not as hard as the first time, and then let go. This time the sound is not as loud.

Repeat the process several times using different pressures.

The harder one presses on the ruler before releasing it, the farther the ruler vibrates and the louder the sound. (Note that the ruler vibrates farther, not faster.) The loudness also depends upon the distance the listener is away from the source of the sound.

"Chinese School"

Purpose: To demonstrate our ability to mask out unwanted sounds.

Procedure: Ask for two volunteers. Arrange a screen (a table may be set on its side) for them to sit behind so the other pupils cannot see them. Give the volunteers several books containing stories with which all the children are already familiar --- Dr. Seuss books, CHARLOTTE'S WEB, CHARLIE IN THE CHOCOLATE FACTORY, THE BOX CAR CHILDREN, or recent stories from the basal reader.

Each volunteer selects a book, finds a page at random, and at a signal, both begin to read at once in a normal tone of voice. Their classmates must identify who is reading which story. A pupil who guesses correctly gets to take the place of the original volunteer, choose his own book, and the readers begin again.

After three or four readers have been "guessed", add a third reader. If the pupils are still guessing correctly, add a fourth reader.

Noise and Your Heartbeat

Purpose: To enable pupils to compare rate of heartbeat in a quiet environment with rate of heartbeat in a noisy environment.

Equipment needed: A watch with sweep second hand. Noise-making utensils or implements.

Procedure: Show pupils how to find pulse in their wrists, or (easier) show where each child can find the large blood vessel in his own throat on either side of his upper windpipe. (Caution: Pressing too hard on the throat will reduce oxygen flow to the brain.)

Rate of heartbeat in a quiet room:

Teacher signals "Begin" and each child counts his heartbeats. Room should be quiet. At the end of thirty seconds, teacher signals "Stop." Each pupil writes down the rate of his own heartbeat.

Rate of heartbeat in a noisy room:

Ask for three volunteers. Take all three of them to the back of the room where their movements will not distract the other pupils.

Give them a book to drop repeatedly on the floor to make a cracking sound, a ruler to tap on a tin pan, or other sound-making devices. The sounds should not be synchronized. The more random they are, the better.

When all pupils are ready to count their heartbeats for the second part of the experiment, the teacher once more signals "Begin." Volunteers create noise. Pupils count their heartbeats. At the end of thirty seconds, the teacher signals "Stop."

Pupils write down the number of heartbeats they counted for the second time period. Pupils may make a chart on the chalkboard and write in their "before" and "after" rates. The noise will definitely affect pulse rate. Some may go up, some may go down. Very few will remain the same.

Noise and Your Brain

Purpose: To enable pupils to compare the skill with which they are able to solve arithmetic problems in a quiet room and in a noisy room.

Equipment needed: Watch with sweep second hand. Noise-making equipment. Two equivalent spirit-duplicated class sets of arithmetic exercises.

Doing arithmetic problems in a quiet room:

Hand out copies of Set 1 face down on each desk. Have each pupil write his name and "Set 1" on the back. When the teacher signals "Begin", each pupil turns over his paper and begins to work his problems. The room is quiet. At the end of one minute, the teacher signals "Stop." Pupils stop work immediately and set aside the Set 1 paper.

Doing arithmetic problems in a noisy room:

Hand out copies of Set 2 face down on each desk. Have each pupil write his name and "Set 2" on the back. Volunteer noise-makers take their places at the back of the room. Teacher signals "Begin" and after one minute, "Stop". Collect the papers.

Appoint monitors to check the answers and return the papers to the children. Explain that pupils will not enter their before-and-after scores on the chalkboard, but will list, instead, the difference between the two scores. For example, if a pupil gets 5 problems correct on Set 1 and only 3 problems correct on Set 2, he will list a score of -2 on the chalkboard. If a pupil makes the same score on both sets, his score is 0. If he has only 3 answers correct on Set 1 and 5 answers correct on Set 2, his score is +2.

Have each pupil in turn list on the chalkboard his name and the difference between his first and second score.

Bibliography:

A Multi-Media Educational Program From EMC Corporation
Our Environment 2, Sound and Noise Teacher's Guide

## SUGGESTED ACTIVITIES

## To Follow Filmstrip

## "QUIET, PLEASE!"

Discussion suggested by frames at the end of the filmstrip

Purpose: To enable pupils to think of ways they can bring about relief from noise pollution.

Procedure: Teacher may ask pupils to write their suggestions on the chalkboard.

Suggested list (answers will vary):

1. Talk only as loud as necessary to be heard.
2. Turn off TV set and radio when no one is there to listen to it.
3. Keep noise levels down in our schools.
4. Plant trees and shrubs to screen the house from street noise.
5. Write letters to the mayor, councilmen, congressmen, regarding noise pollution measures.
6. Observe quiet signs and zones.
7. Go to visit a place where everything is really quiet so you won't "forget what silence sounds like."

Wall Chart

The wall chart included with the SOUND AND NOISE kit shows representative sources of sound, their relative intensity (loudness) in decibels, and their effect on human beings. The chart may be used as a visual reference to reinforce and expand the filmstrip sequence (cf. Frames 5 through 11) comparing various noise levels, as well as a visual focal point for classroom discussion. Pupils may be invited to suggest everyday sources of sound in addition to those listed on the chart, and to estimate their relative position on the "loudness" scale, as well as their comparative effect on humans.

Noise Pollution in Our School

The pupils may make a tour of the school and make notes about especially noisy places. From what they learned on the sound-filmstrip, they may speculate about the sound level (decibels) in the cafeteria, the school

corridors, the band room, the playground. If equipment may be borrowed, actual sound measurements may be taken. When the pupils return to the classroom, each child may select a "noisy place" of his own and write a paragraph making suggestions about how it could be made more quiet.

Guest Speaker

Invite the manager of the local airport to come talk to the class about airport noise. How great is the problem in your city? What is being done to combat it? What federal regulations have recently been passed to cope with airplane noise? How do employees who service jet planes protect themselves from excessive noise?

Research Project

Assign different members of the class to find out about your city and state laws to control noise. Have any changes been made within the last six months? What changes are likely to occur within the next six months?

Field Trip

Visit a neighborhood near an airport or freeway and interview people regarding the noise problem in their area. How objectionable is the noise of the airport or of freeway traffic? Does it interfere with home activities, and if so, in what ways? What measures, if any, has the family taken to counteract the noise problem? Is it necessary, for example, to keep doors and windows shut even in the warm weather months?

Field Trip

Find out if there is a factory in your city where noise is an especially difficult problem. Arrange a tour of the factory to find out what different measures have been taken to control noise there.

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NOTES

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